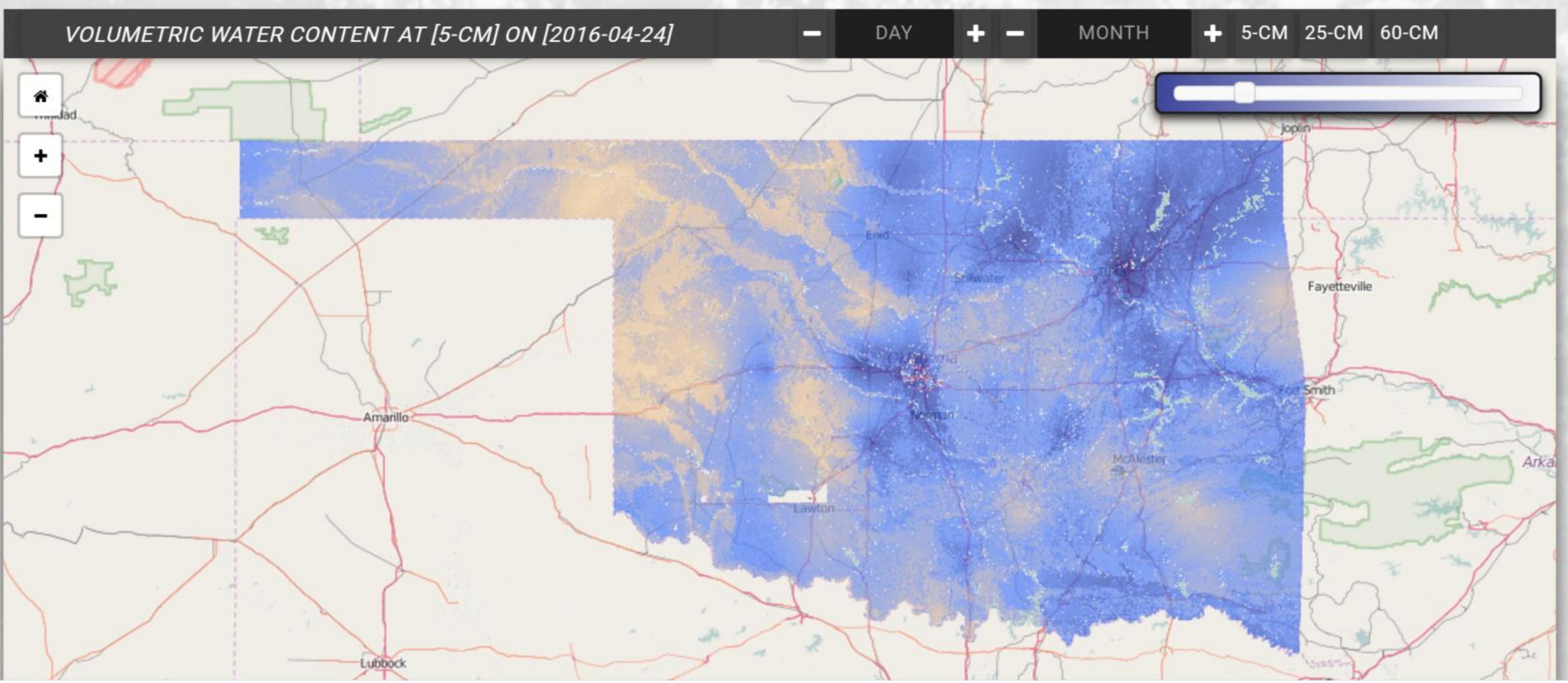
Large-scale soil moisture monitoring in Oklahoma



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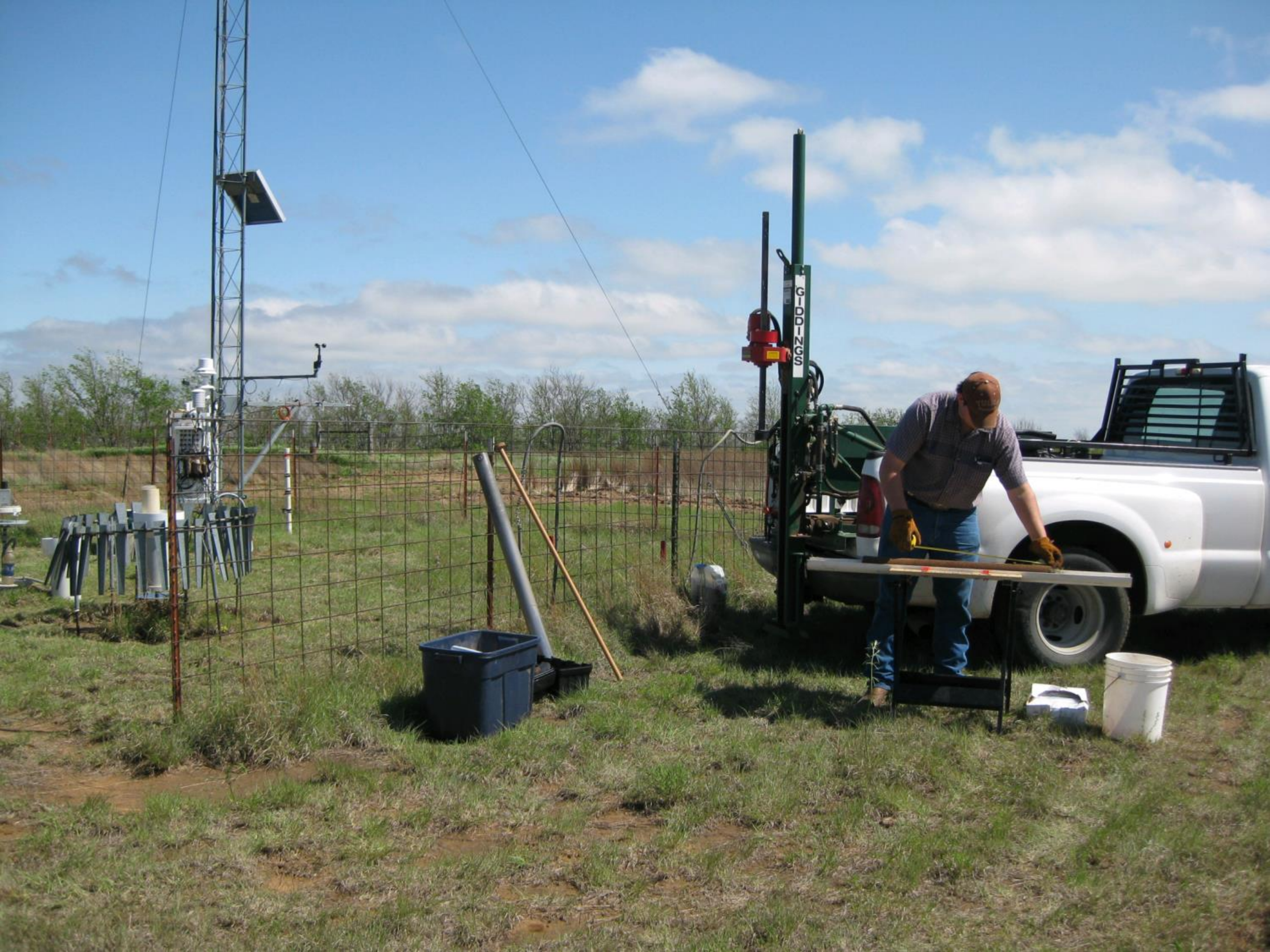
National Soil Moisture Network Workshop,
Boulder, CO, May 25, 2016

Based on work supported by the National Science Foundation under Grant No. OIA-1301789


GIDDINGS

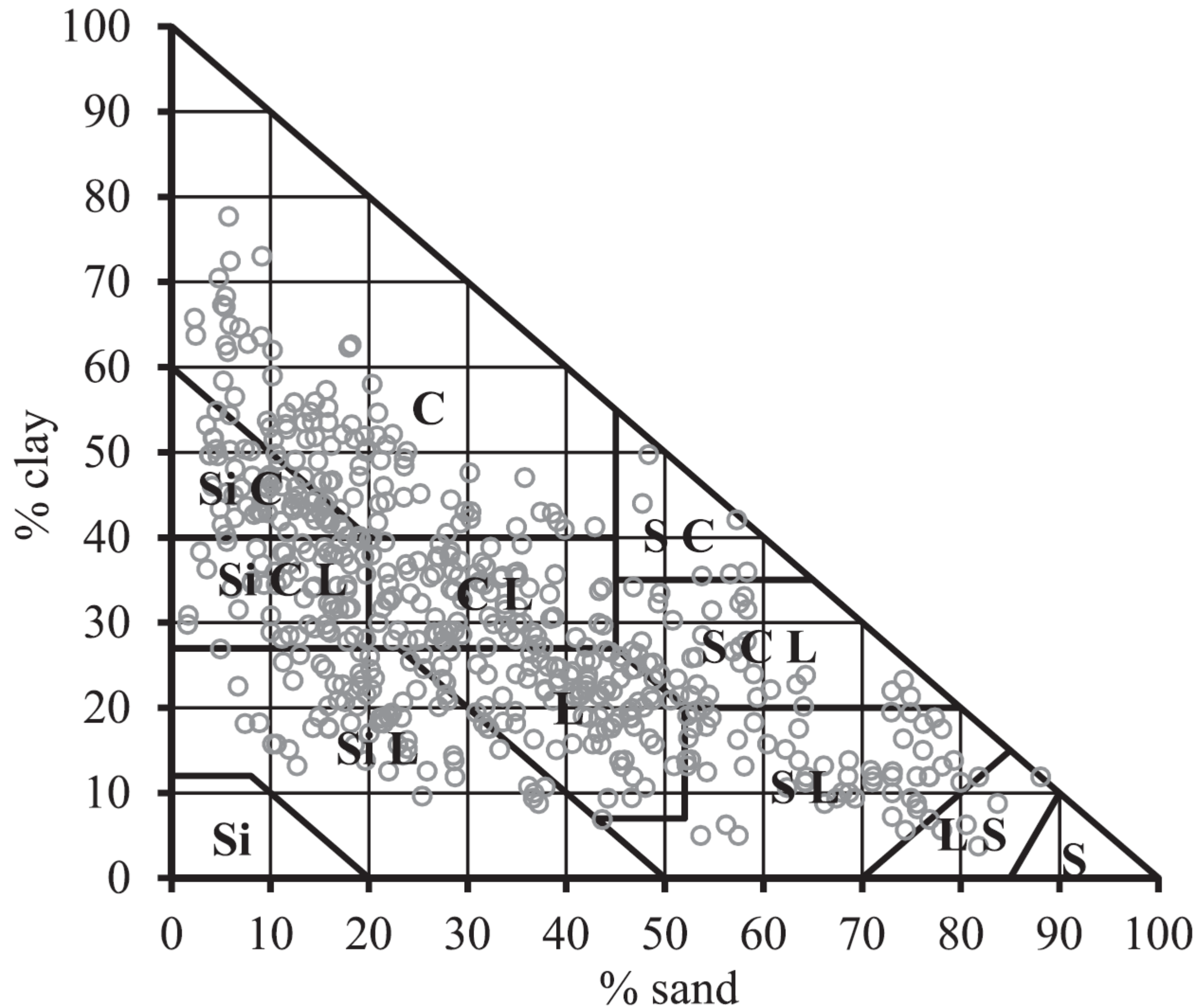


FIG. 2. Particle size distribution for the soils of the Oklahoma Mesonet stations at the sampled depths.

TABLE 1. Number of samples in each textural class (N) and textural class mean and standard deviation of bulk density (ρ_b), percent sand, percent clay, water content at -33 kPa (θ_{-33}), and water content at -1500 kPa (θ_{-1500}). Abbreviated textural classes are loamy sand (L sand), sandy clay (S clay), sandy clay loam (S C L), sandy loam (S loam), silty clay loam (Si C L), silty clay (Si clay), and silt loam (Si loam).

Textural class	N	ρ_b (g cm^{-3})		Sand (%)		Clay (%)		θ_{-33} (cm^3 cm^{-3})		θ_{-1500} (cm^3 cm^{-3})	
Clay	85	1.52	(0.16)	17.4	(9.4)	52.8	(8.6)	0.38	(0.06)	0.25	(0.05)
C loam	83	1.51	(0.15)	30.6	(6.3)	32.9	(3.7)	0.28	(0.05)	0.15	(0.04)
Loam	85	1.46	(0.15)	41.1	(6.0)	20.7	(4.2)	0.23	(0.05)	0.09	(0.03)
L sand	6	1.49	(0.21)	81.7	(3.8)	6.9	(2.9)	0.09	(0.02)	0.02	(0.01)
Sand	N/A	—	—	—	—	—	—	—	—	—	—
S clay	6	1.67	(0.15)	53.7	(4.6)	40.5	(5.8)	0.34	(0.03)	0.21	(0.03)
S C L	37	1.57	(0.19)	55.7	(7.4)	25.8	(4.1)	0.22	(0.05)	0.12	(0.04)
S loam	58	1.51	(0.21)	66.5	(9.5)	12.8	(3.9)	0.16	(0.05)	0.06	(0.02)
Silt	N/A	—	—	—	—	—	—	—	—	—	—
Si C L	56	1.45	(0.20)	13.2	(4.7)	33.9	(3.7)	0.28	(0.05)	0.10	(0.03)
Si clay	55	1.58	(0.13)	9.9	(4.3)	45.3	(3.6)	0.38	(0.05)	0.25	(0.05)
Si loam	70	1.48	(0.18)	21.1	(7.6)	18.7	(4.6)	0.31	(0.05)	0.17	(0.05)

TABLE 2. Textural class average hydraulic parameter lookup table for the soils of the Oklahoma Mesonet. Number of samples in each textural class (N) and textural class average residual water content (θ_r), saturated water content (θ_s), fitting parameters α and n, saturated hydraulic conductivity (K_s), fitted matching point at saturation (K_0), and empirical parameter (L). See Table 1 for textural class expansions.

Textural class	N	θ_r ($cm^3 cm^{-3}$)		θ_s ($cm^3 cm^{-3}$)		α (kPa^{-1})		n (unitless)		K_s (cm day^{-1})		K_0 (cm day^{-1})		L (unitless)	
Clay	85	0.07	(0.01)	0.45	(0.04)	0.13	(0.10)	1.26	(0.10)	11.3	(15.2)	3.5	(3.2)	−1.2	(1.5)
C loam	83	0.06	(0.01)	0.40	(0.03)	0.16	(0.12)	1.36	(0.11)	13.7	(11.5)	7.1	(9.1)	−0.7	(0.7)
Loam	85	0.04	(0.01)	0.38	(0.03)	0.16	(0.10)	1.43	(0.10)	22.7	(14.7)	8.7	(8.1)	−0.4	(0.6)
L sand	6	0.02	(0.01)	0.38	(0.05)	0.58	(0.15)	1.55	(0.15)	302.5	(201)	67.0	(48.2)	−1.1	(0.1)
Sand	N/A	—	—	—	—	—	—	—	—	—	—	—	—	—	—
S clay	6	0.06	(0.01)	0.39	(0.04)	0.11	(0.11)	1.28	(0.06)	16.8	(33.0)	3.9	(4.4)	−0.6	(1.1)
S C L	37	0.05	(0.01)	0.38	(0.04)	0.29	(0.16)	1.35	(0.06)	60.0	(73.2)	16.9	(19.1)	−1.2	(0.6)
S loam	58	0.03	(0.01)	0.37	(0.05)	0.35	(0.18)	1.41	(0.08)	101.5	(97.6)	26.6	(22.5)	−0.9	(0.6)
Silt	N/A	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Si clay	55	0.08	(0.01)	0.43	(0.03)	0.16	(0.11)	1.25	(0.12)	3.7	(4.4)	3.5	(2.1)	−2.2	(2.3)
Si C L	56	0.07	(0.03)	0.42	(0.03)	0.16	(0.12)	1.36	(0.13)	10.3	(7.2)	5.4	(7.6)	−1.1	(1.8)
Si loam	70	0.04	(0.02)	0.39	(0.04)	0.09	(0.10)	1.58	(0.25)	22.5	(27.1)	4.6	(6.2)	0.1	(0.6)

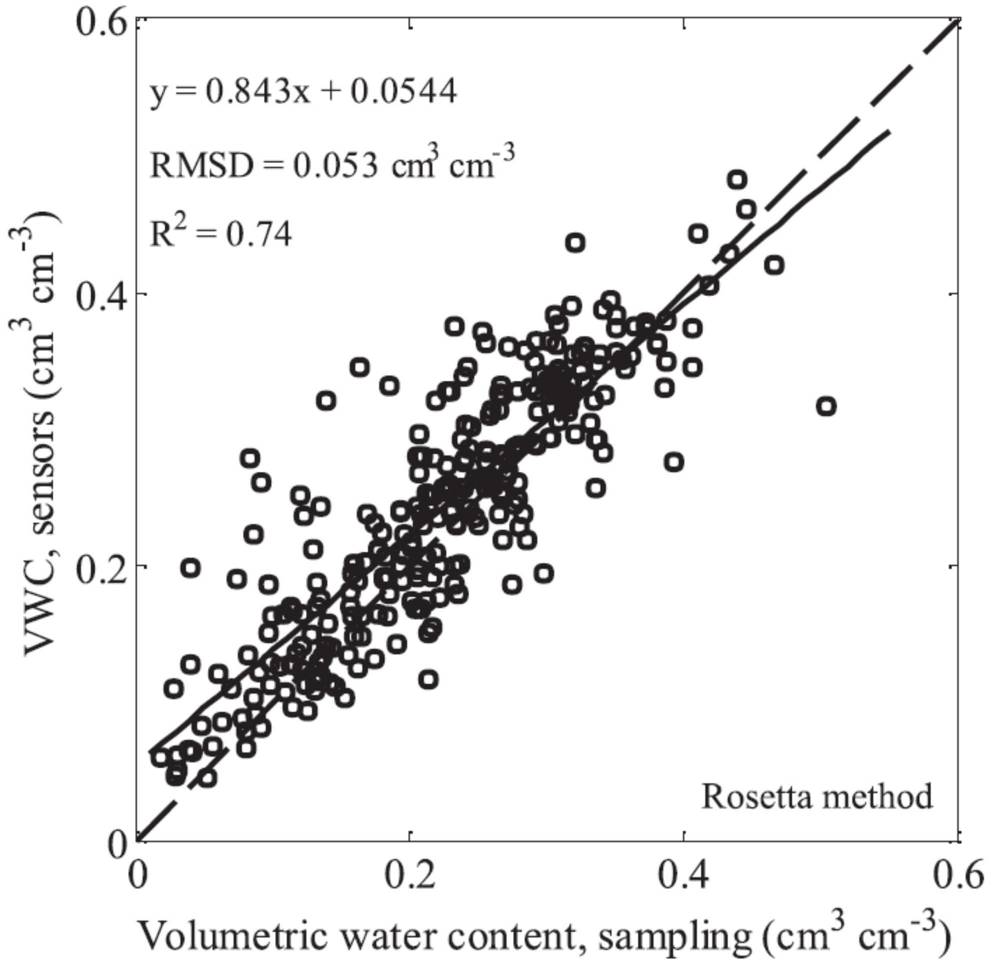
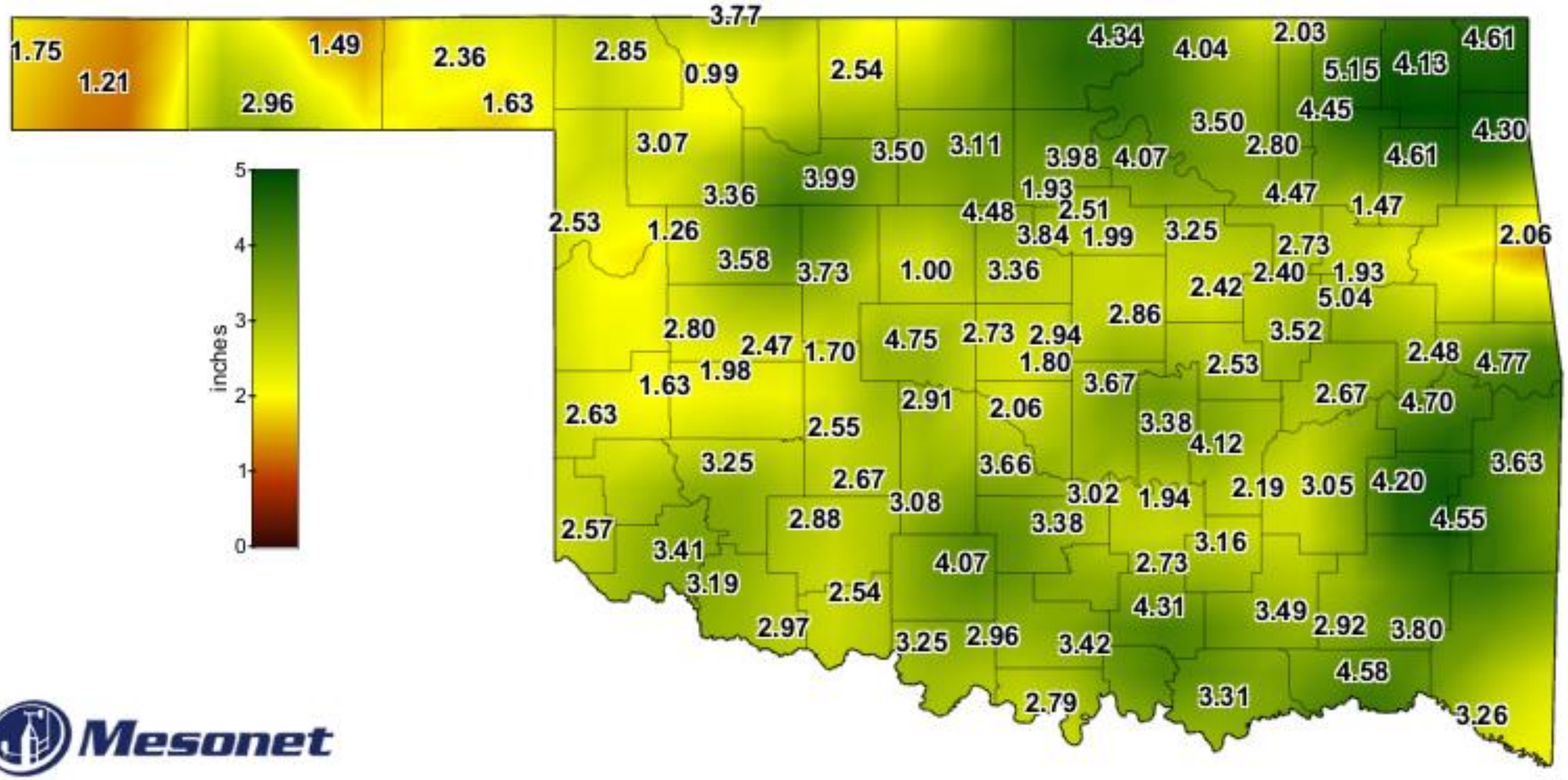


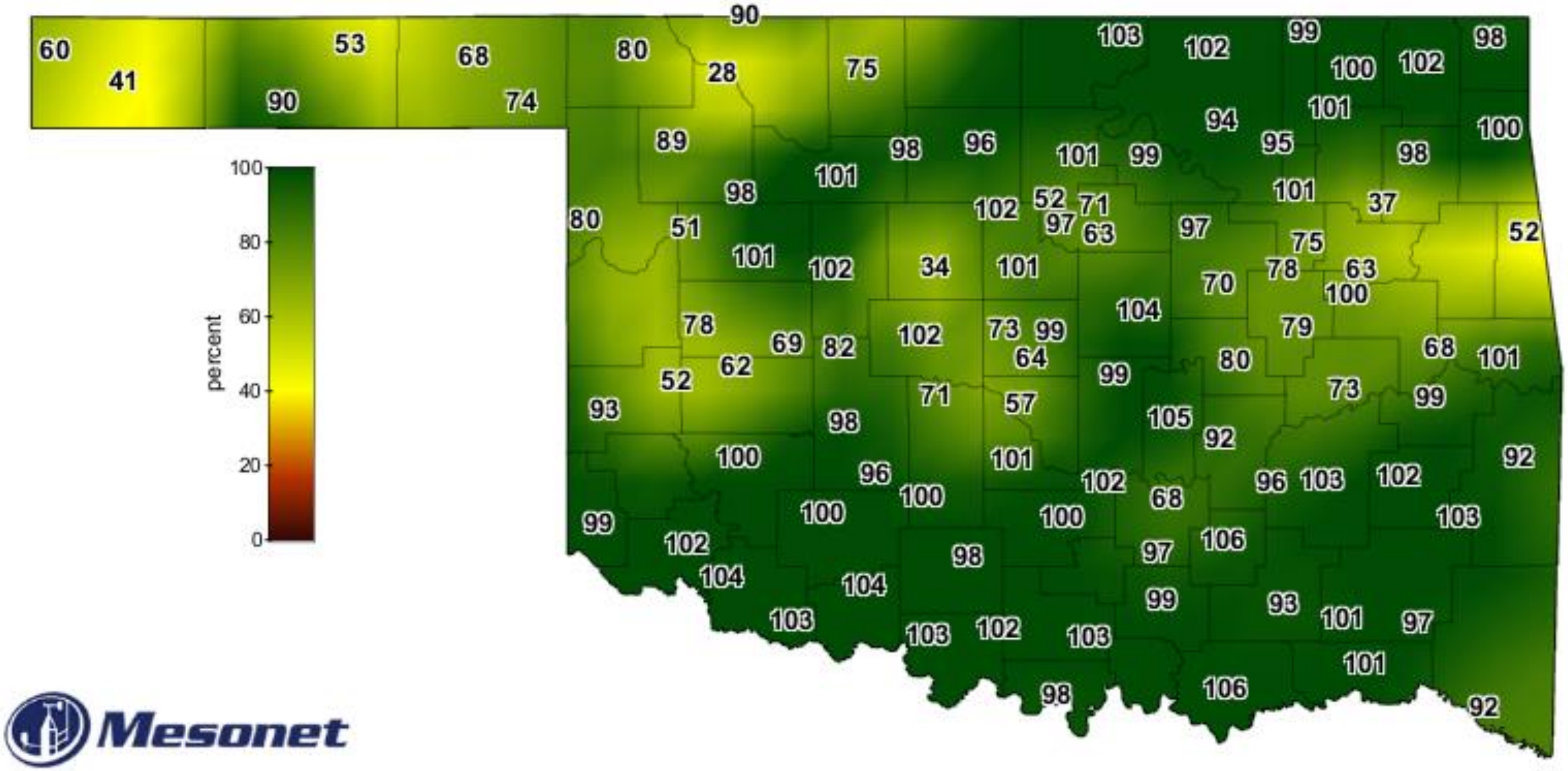
FIG. 6. Volumetric water content (VWC) calculated from the daily average ΔT_{ref} output from the Oklahoma Mesonet heat dissipation sensors on the day of soil sampling (sensors) vs VWC determined by oven drying a subsample of the core section. The ΔT_{ref} values were converted to ψ_m by Eq. (4) and then to VWC by Eq. (1) using the parameters in the new database. The symbols are the VWC data, the solid line is the regression line, and the dashed line is the 1:1 line.



Mesonet

1-day Average 16-inch Plant Available Water

May 24, 2016

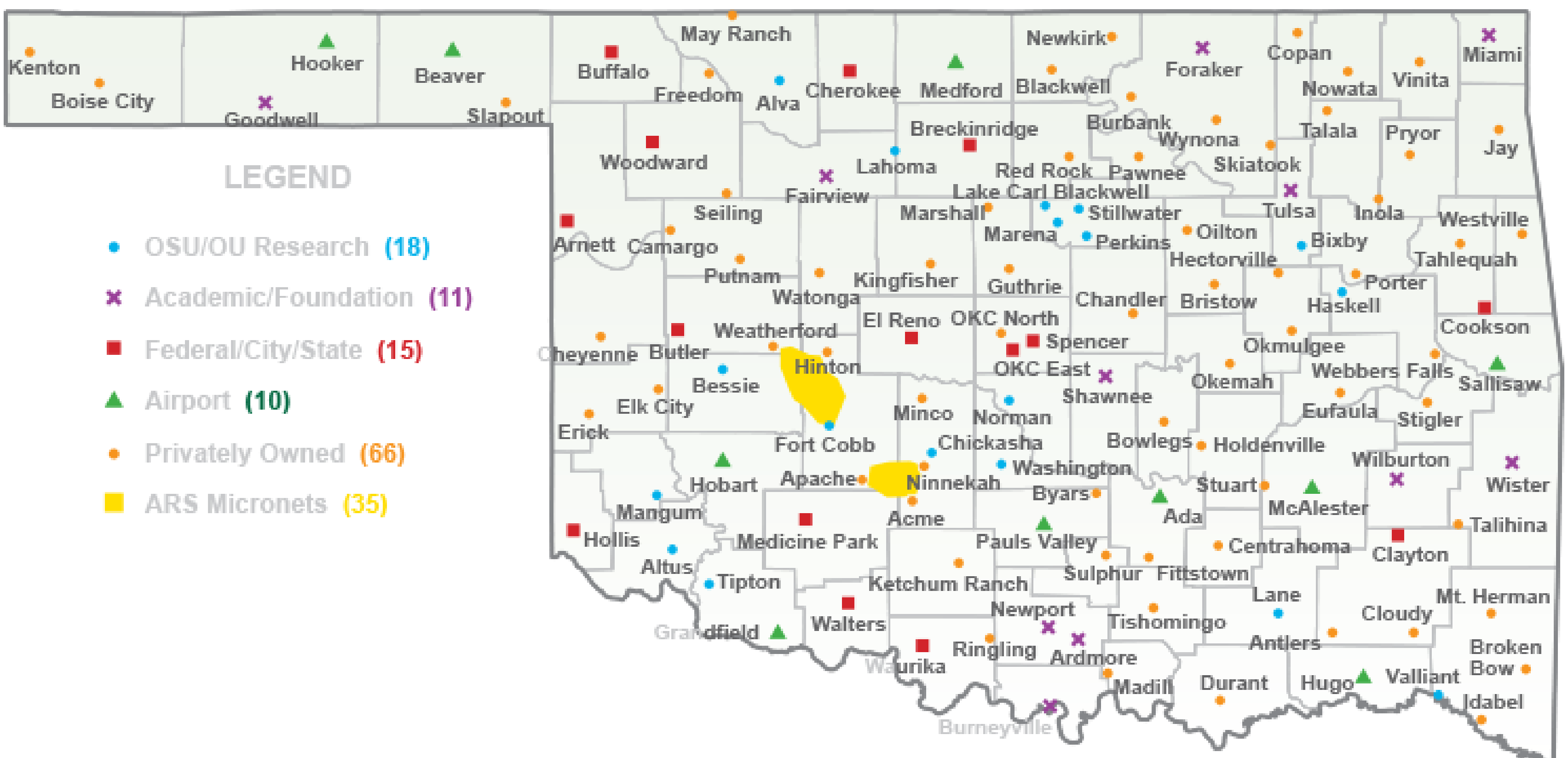


1-day Average 16-inch Percent Plant Available Water

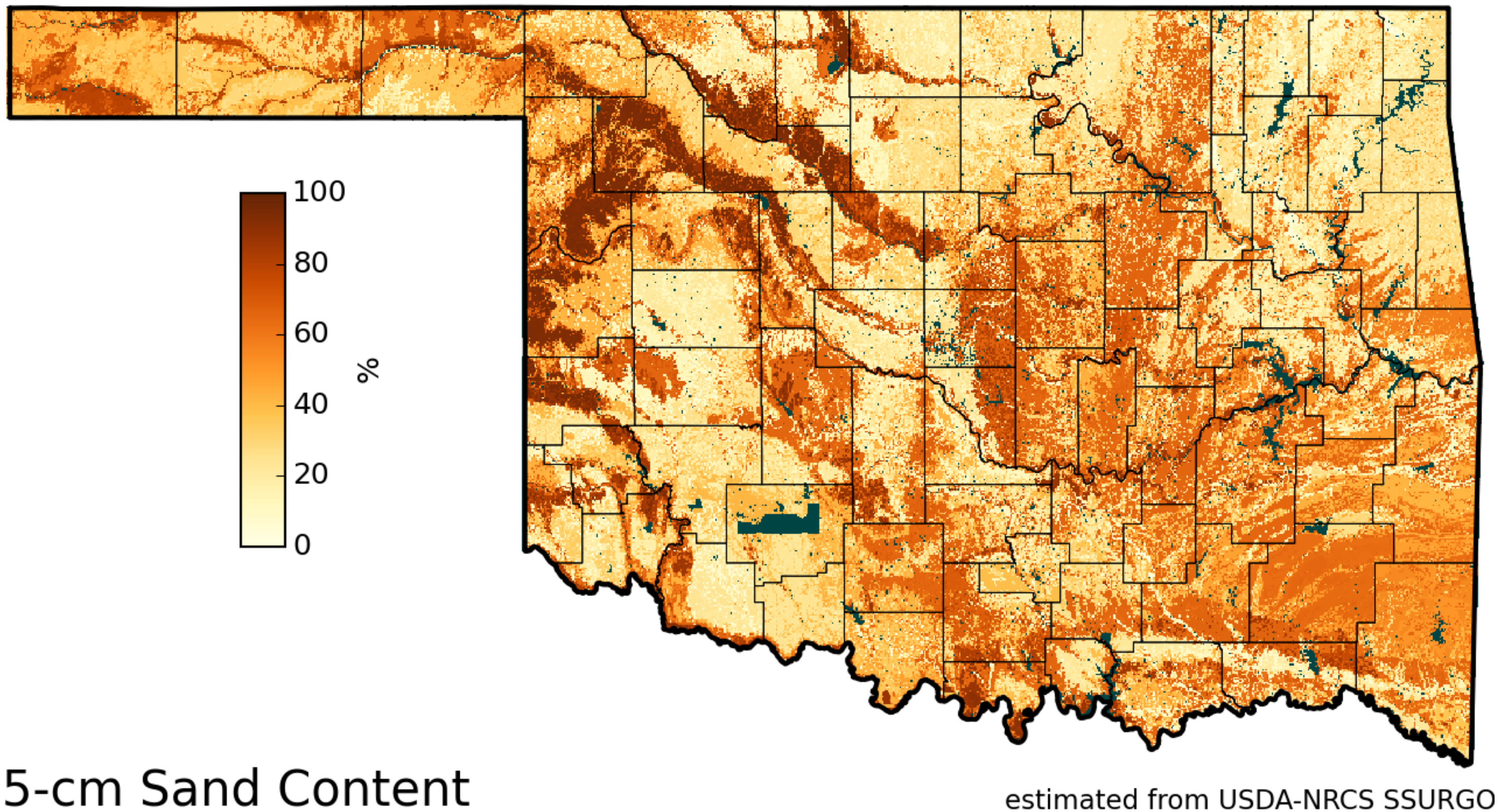
May 24, 2016

How can we best map field scale soil moisture across the state?

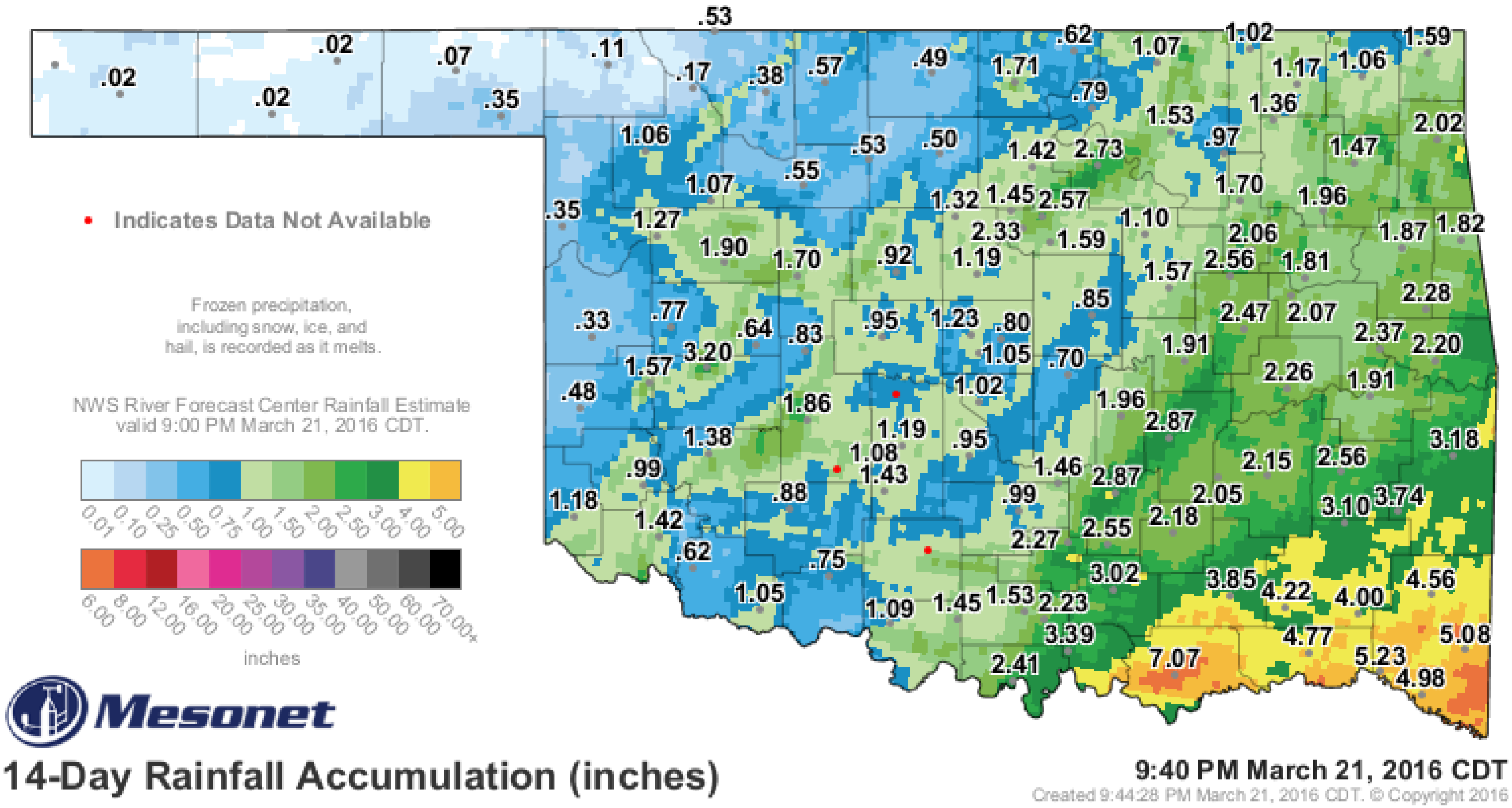
- Average of one in-situ measurement per 1680 km^2
- Existing in-situ sensors have measurement volume of ~100 cm^3



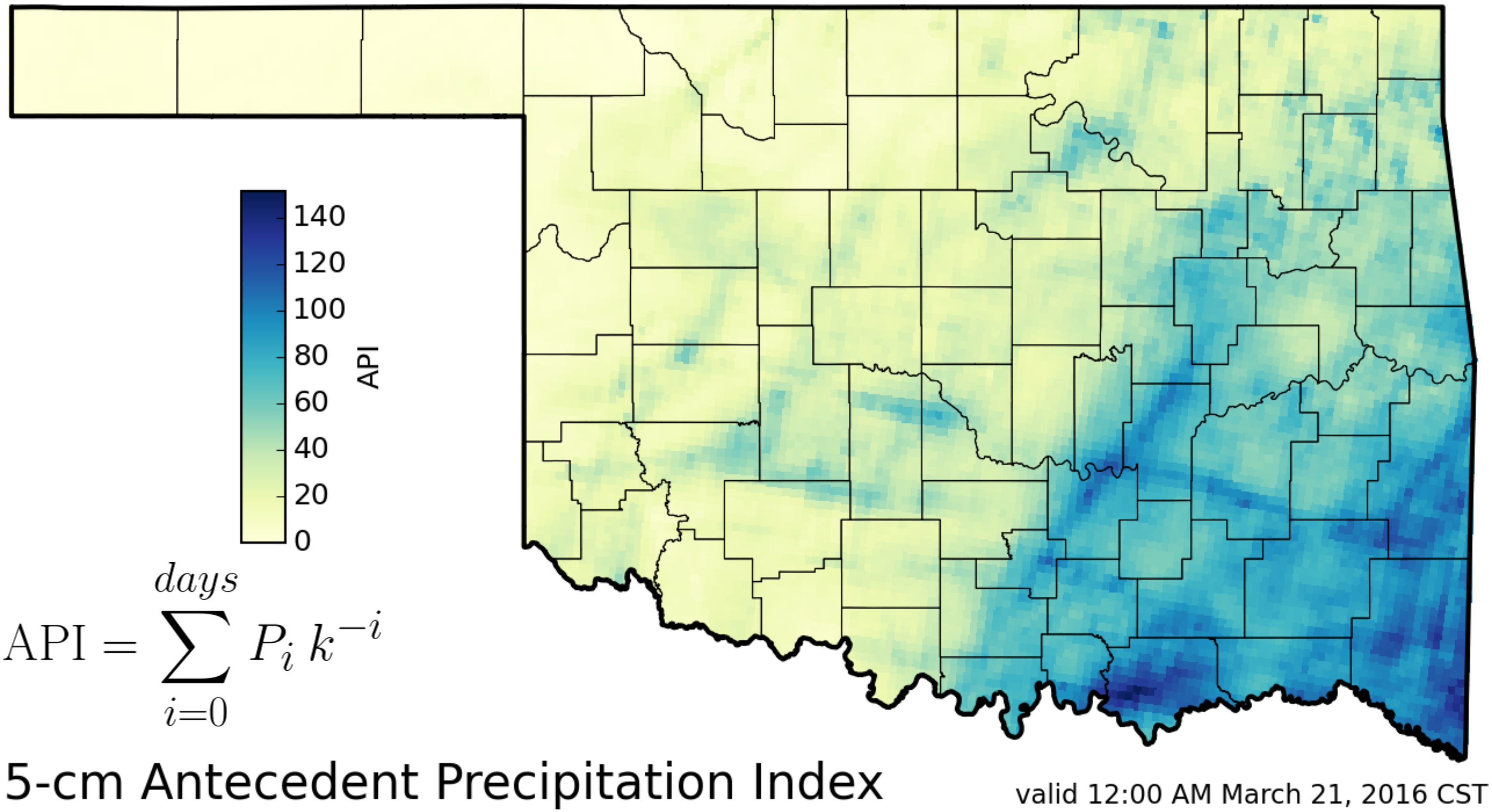
Using soil texture information



Using radar-based precipitation



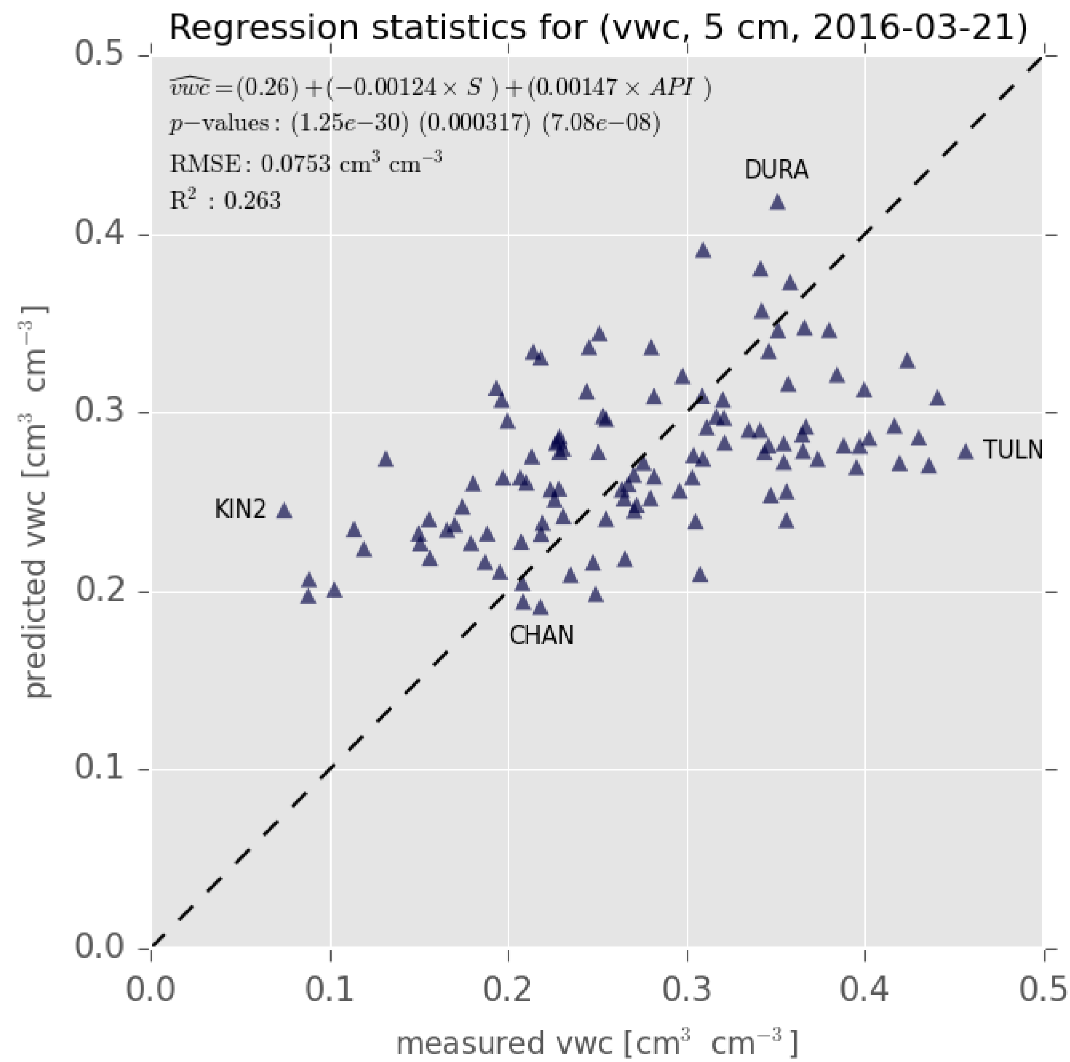
Allowing for the soil's "memory"



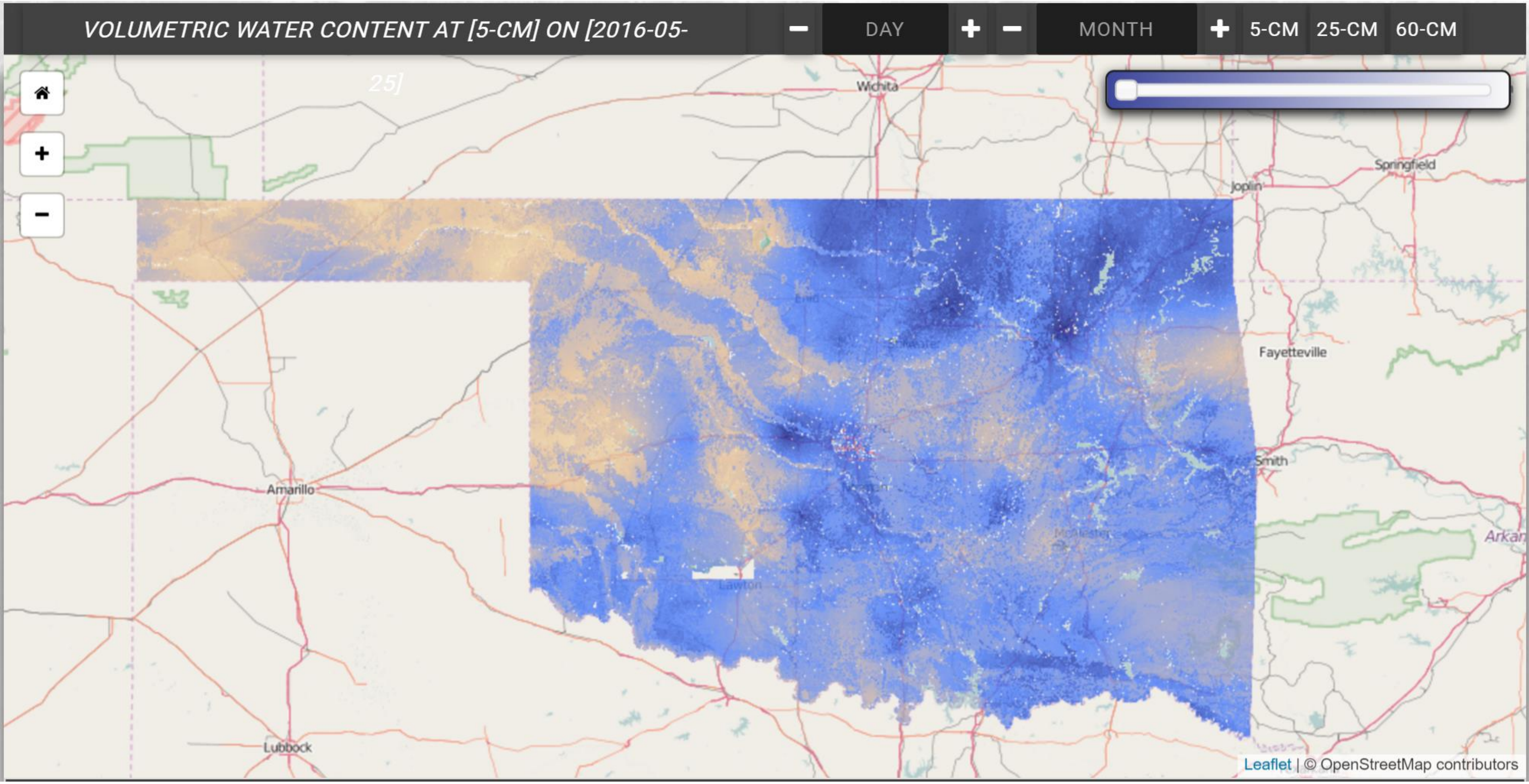
$$\mathrm{API} = \sum_{i=0}^{days} P_i \, k^{-i}$$

5-cm Antecedent Precipitation Index

Apply regression-kriging approach



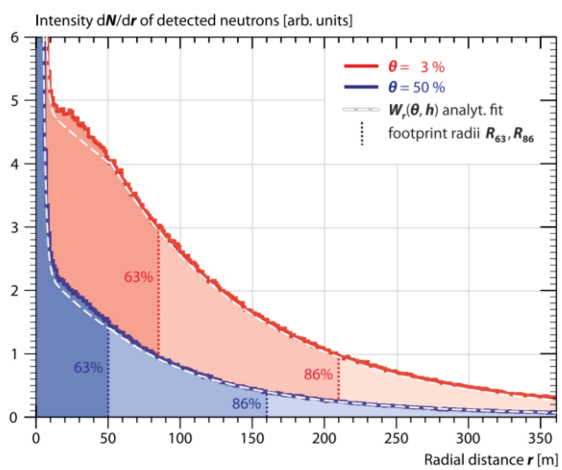
Daily, 800-m gridded soil moisture data

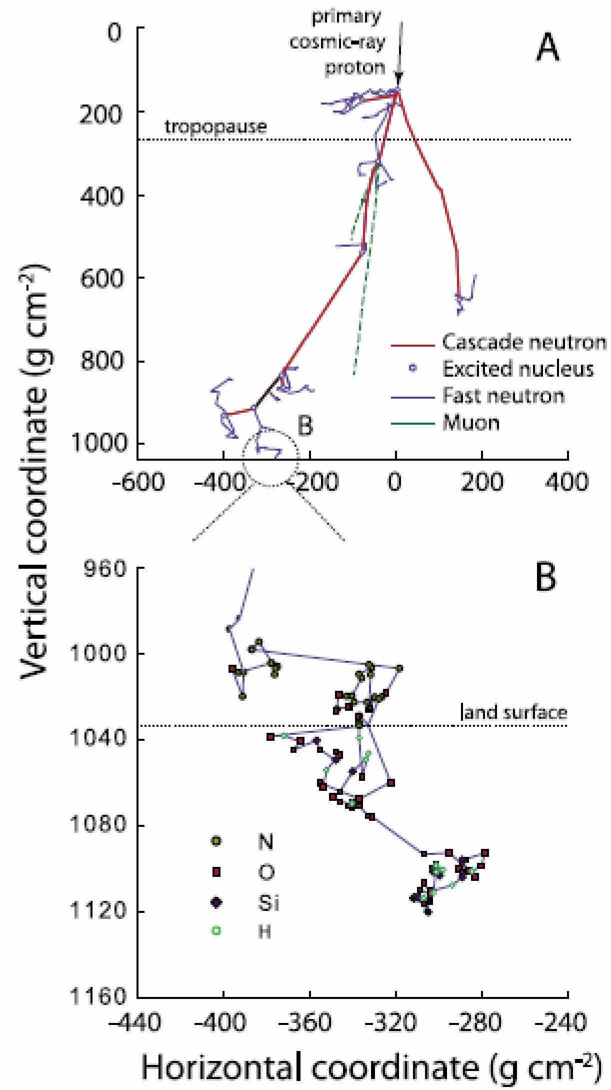


http://soilmoisture.okstate.edu/

Cimarron River Transect Study

- Cosmic-ray neutron method
- Large mobile neutron detector, the Rover





Cimarron River Transect Study

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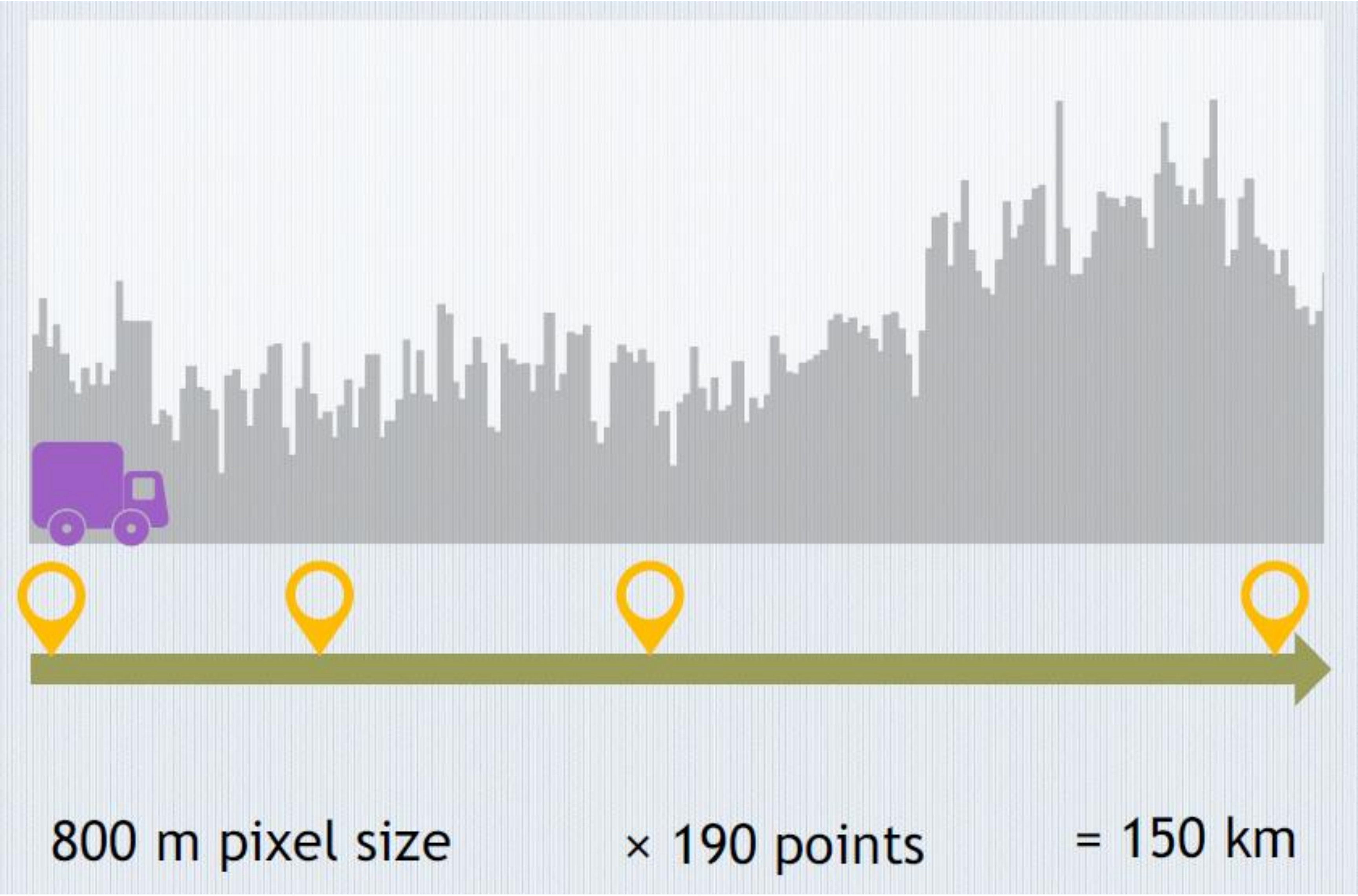
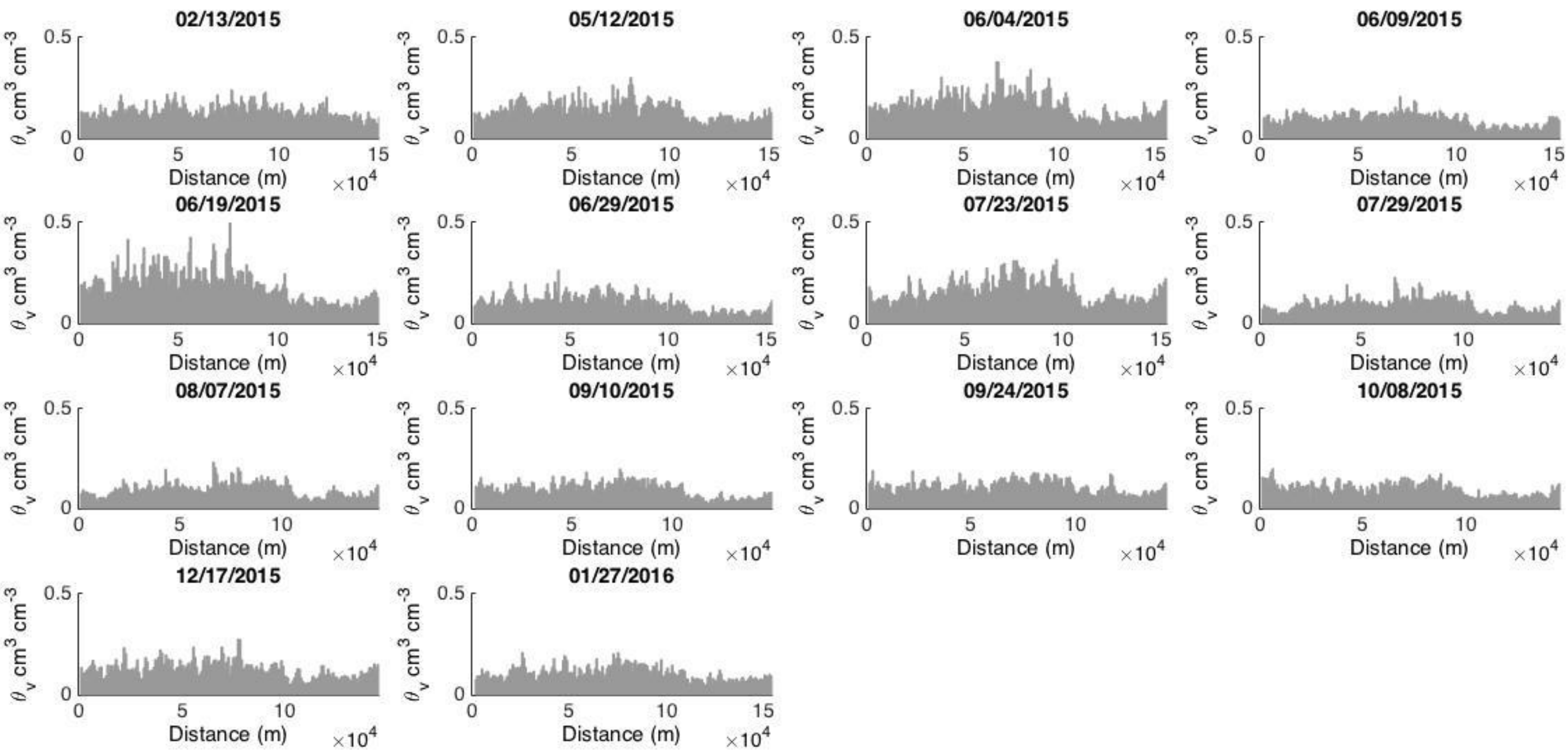


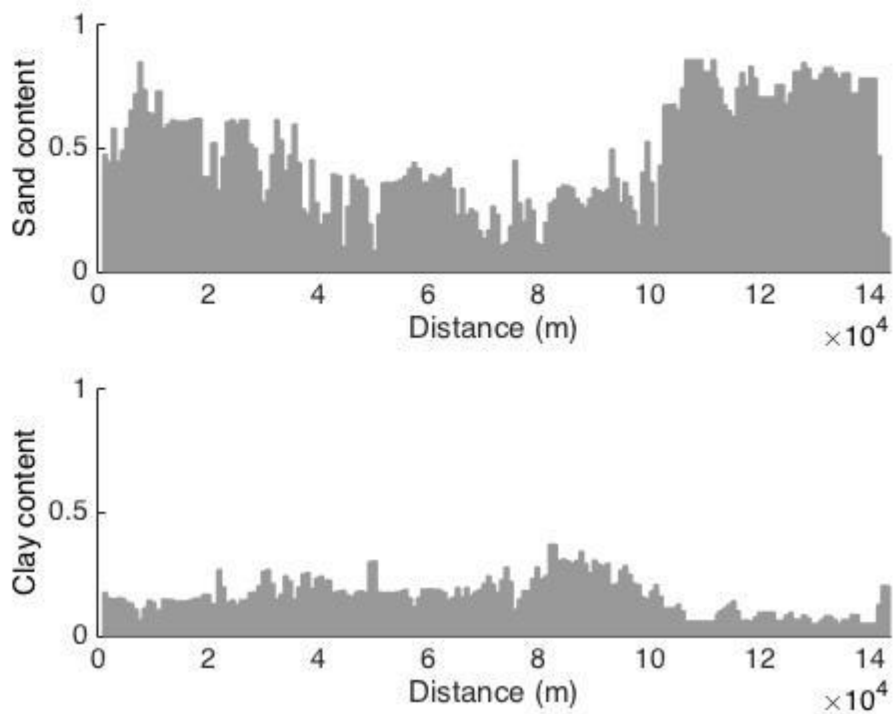
Soil moisture transects

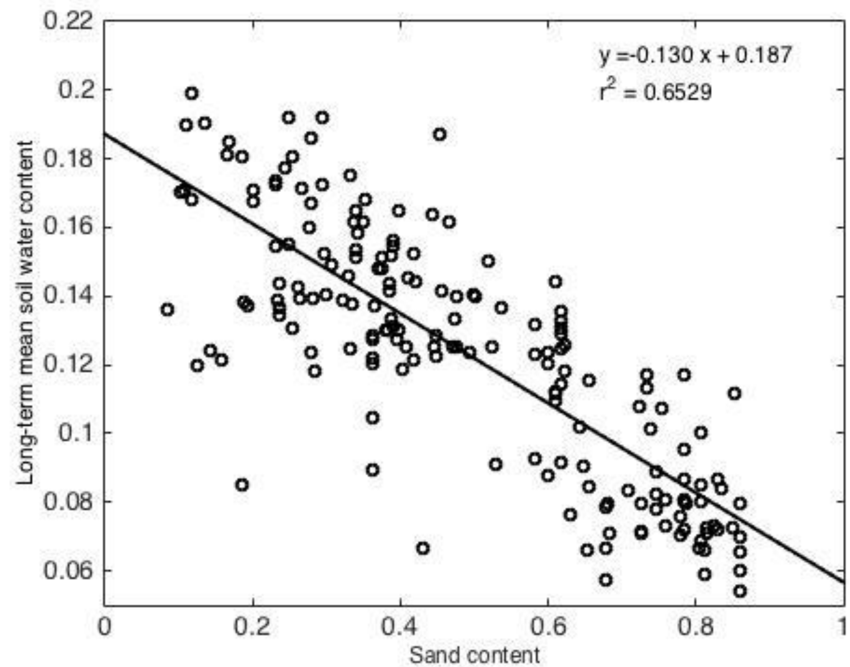
- Persistent low soil moisture for western third
- Maximum variability after rainfall on eastern half



Soil texture is one main driver

- High sand contents for the western third overlying the Cimarron River alluvial aquifer
- Mean soil moisture - sand content strongly related





Needs, gaps, and unknowns

- Harmonization of data given differing sensors and depths

- Soil moisture conditions under
  - Rainfed cropland
  - Irrigated cropland
  - Deciduous forest
  - Evergreen forest

- Development of applications
  - Wildfire
  - Groundwater recharge
  - Human health
  - Many others

Green = we have some progress to show; Yellow = we are working on it